

Amendments to the Claims

The following listing of claims will replace all prior versions and/or listings of claims in the application:

Listing of claims:

1-2192. (cancelled)

2193. (currently amended): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heaters disposed in the formation to at least a ~~portion~~ section of the formation such that an average heating rate of a part of the formation is less than about 1 °C per day in a pyrolysis temperature range; and

allowing the heat to transfer from the one or more heaters to the part of the formation such that a permeability of at least a portion of the part of the formation increases to greater than about 100 millidarcy.

61 2194. (previously presented): The method of claim 2193, wherein the one or more heaters comprise at least two heaters, and wherein controlled superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons in the part of the formation.

2195. (previously presented): The method of claim 2193, further comprising maintaining a temperature in the part of the formation in a pyrolysis temperature range of about 270 °C to about 400 °C.

2196. (currently amended): The method of claim 2193, wherein at least one of the ~~one or more~~ heaters comprises an electrical heater.

2197. (currently amended): The method of claim 2193, wherein at least one of the ~~one or more~~ heaters comprises a surface burner.

2198. (currently amended): The method of claim 2193, wherein at least one of the ~~one or more~~ heaters comprises a flameless distributed combustor.

2199. (currently amended): The method of claim 2193, wherein at least one of the ~~one or more~~ heaters comprises a natural distributed combustor.

2200. (previously presented): The method of claim 2193, further comprising controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2201. (cancelled)

2202. (currently amended): The method of claim 2193, wherein providing heat from one or more of the heaters to at least the ~~portion~~ section of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from one or more of the heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (P_{wr}) provided to the selected volume is equal to or less than $h \cdot V \cdot C_v \cdot \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is ~~about 10~~ about 1 °C/day.

2203. (original): The method of claim 2193, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

2204. (previously presented): The method of claim 2193, wherein providing heat from one or more of the heaters increases a thermal conductivity of at least a portion of the part of the

formation to greater than about 0.5 W/(m °C).

2205. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

2206. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2207. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2208. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

GI 2209. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

2210. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

2211. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

2212. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2213. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2214. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

GI 2215. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

2216. (currently amended): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises a non-condensable component at 25 °C and one atmosphere absolute pressure, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

2217. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

2218. (original): The method of claim 2193, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2219. (previously presented): The method of claim 2193, further comprising controlling a pressure in at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

2220. (previously presented): The method of claim 2193, further comprising controlling formation conditions to produce a mixture from the formation, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

2221. (previously presented): The method of claim 2220, wherein the partial pressure of H₂ in the mixture is measured when the mixture is at a production well.

GI 2222. (previously presented): The method of claim 2193, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

2223. (original): The method of claim 2193, further comprising producing a mixture from the formation and controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

2224. (previously presented): The method of claim 2193, further comprising:
providing hydrogen (H₂) to the heated part of the formation to hydrogenate hydrocarbons in the part of the formation; and

heating a portion of the part of the formation with heat from hydrogenation.

2225. (original): The method of claim 2193, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion
of the produced hydrogen.

2226. (previously presented): The method of claim 2193, further comprising increasing a
permeability of a majority of the part of the formation to greater than about 5 Darcy.

2227. (previously presented): The method of claim 2193, wherein allowing the heat to transfer
increases a permeability of a majority of the part of the formation such that the permeability of
the majority of the part of the formation is substantially uniform.

2228. (previously presented): The method of claim 2193, further comprising controlling the
heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by a
Fischer Assay.

GI 2229. (previously presented): The method of claim 2193, further comprising producing a
mixture in a production well, wherein at least about 7 heaters are disposed in the formation for
each production well.

2230. (previously presented): The method of claim 2193, further comprising providing heat
from three or more heaters to at least a portion of the formation, wherein three or more of the
heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises
a triangular pattern.

2231. (previously presented): The method of claim 2193, further comprising providing heat
from three or more heaters to at least a portion of the formation, wherein three or more of the
heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a

triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

2232. (currently amended): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heaters disposed in the formation to at least a ~~portion~~ section of the formation such that an average heating rate of a part of the formation is less than about 1 °C per day in a pyrolysis temperature range; and

allowing the heat to transfer from the one or more heaters to the part of the formation to increase a permeability of a majority of the part of the formation such that the permeability of the majority of the part is substantially uniform.

2233. (previously presented): The method of claim 2232, wherein the one or more heaters comprise at least two heaters, and wherein controlled superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons in the part of the formation.

2234. (previously presented): The method of claim 2232, further comprising maintaining a temperature in the part of the formation in a pyrolysis temperature range of about 270 °C to about 400 °C.

2235. (currently amended): The method of claim 2232, wherein at least one of the ~~one or more~~ heaters comprises an electrical heater.

2236. (currently amended): The method of claim 2232, wherein at least one of the ~~one or more~~ heaters comprises a surface burner.

2237. (currently amended): The method of claim 2232, wherein at least one of the ~~one or more~~ heaters comprises a flameless distributed combustor.

2238. (currently amended): The method of claim 2232, wherein at least one of the ~~one or more~~ heaters comprises a natural distributed combustor.

2239. (previously presented): The method of claim 2232, further comprising controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

2240. (cancelled)

2241. (currently amended): The method of claim 2232, wherein providing heat from one or more of the heaters to at least the ~~portion~~ section of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from one or more of the heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is ~~about 10~~ about 1 °C/day.

2242. (original): The method of claim 2232, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

2243. (previously presented): The method of claim 2232, wherein providing heat from one or more of the heaters increases a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

2244. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

2245. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

2246. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

2247. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

2248. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

61 2249. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

2250. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

2251. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

2252. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

2253. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

2254. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

61 2255. (currently amended): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises a non-condensable component at 25 °C and one atmosphere absolute pressure, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

2256. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

2257. (original): The method of claim 2232, further comprising producing a mixture from the formation, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

2258. (previously presented): The method of claim 2232, further comprising controlling a pressure in at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bar absolute.

2259. (previously presented): The method of claim 2232, further comprising controlling formation conditions to produce a mixture from the formation, wherein a partial pressure of H_2 in the mixture is greater than about 0.5 bar.

2260. (previously presented): The method of claim 2232, further comprising producing a mixture from the formation, wherein a partial pressure of H_2 in the mixture is measured when the mixture is at a production well.

2261. (previously presented): The method of claim 2232, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

GI 2262. (original): The method of claim 2232, further comprising producing a mixture from the formation and controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

2263. (previously presented): The method of claim 2232, further comprising:
providing hydrogen (H_2) to the heated part to hydrogenate hydrocarbons in the part; and
heating a portion of the part with heat from hydrogenation.

2264. (previously presented): The method of claim 2232, further comprising:
producing hydrogen (H_2) and condensable hydrocarbons from the formation; and

hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

2265. (previously presented): The method of claim 2232, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

2266. (previously presented): The method of claim 2232, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by a Fischer Assay.

2267. (previously presented): The method of claim 2232, further comprising producing a mixture in a production well, wherein at least about 7 heaters are disposed in the formation for each production well.

2268. (previously presented): The method of claim 2232, further comprising providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

61 2269. (previously presented): The method of claim 2232, further comprising providing heat from three or more heaters to at least a portion of the formation, wherein three or more of the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

2270-5395. (cancelled)

5396. (previously presented): The method of claim 2229, wherein at least about 20 heaters are disposed in the formation for each production well.

5397. (previously presented): The method of claim 2267, wherein at least about 20 heaters are disposed in the formation for each production well.

5398. (previously presented): The method of claim 2193, wherein the part of the formation comprises a selected section.

5399. (previously presented): The method of claim 2193, wherein a pyrolysis zone is established in the part of the formation.

5400. (previously presented): The method of claim 2193, wherein at least one of the heaters is disposed in an open wellbore.

5401. (previously presented): The method of claim 2232, wherein the part of the formation comprises a selected section.

5402. (previously presented): The method of claim 2232, wherein a pyrolysis zone is established in the part of the formation.

5403. (previously presented): The method of claim 2232, wherein at least one of the heaters is disposed in an open wellbore.

5404. (currently amended): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from heaters disposed in the formation to a ~~portion~~section of the formation to produce heated zones adjacent to the heaters, wherein at least one of the heaters comprises a natural distributed combustor;

allowing the heat to transfer from the heated zones to form a pyrolysis zone, wherein an average temperature in the pyrolysis zone is at a temperature sufficient to pyrolyze hydrocarbons; and

allowing the heat to transfer to the pyrolysis zone from the heated zones at rates sufficient to increase a permeability of the pyrolysis zone such that the permeability in the pyrolysis zone is substantially uniform.

5405. (previously presented): The method of claim 5404, wherein the pyrolysis zone comprises a selected section.

5406. (cancelled)

5407. (previously presented): The method of claim 5404, wherein at least one of the heaters is disposed in an open wellbore.

5408. (previously presented): The method of claim 5404, further comprising producing a mixture from the pyrolysis zone, wherein the mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5409. (previously presented): The method of claim 5404, further comprising controlling a pressure and a temperature in at least a majority of the pyrolysis zone, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

5410. (currently amended): The method of claim 5404, wherein providing heat from the heaters to the ~~portion~~section of the formation comprises:

heating a selected volume (V) of the formation from one or more of the heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.
